NASA Earth Remote Sensing Resources for Public Health:

A Thermodynamic Paradigm for Studying Disease Habitats Using NASA's NextGen Remote Sensing Instruments

Jeffrey C. Luvall
NASA Marshall Space Flight Center
Huntsville, AL
jluvall@nasa.gov

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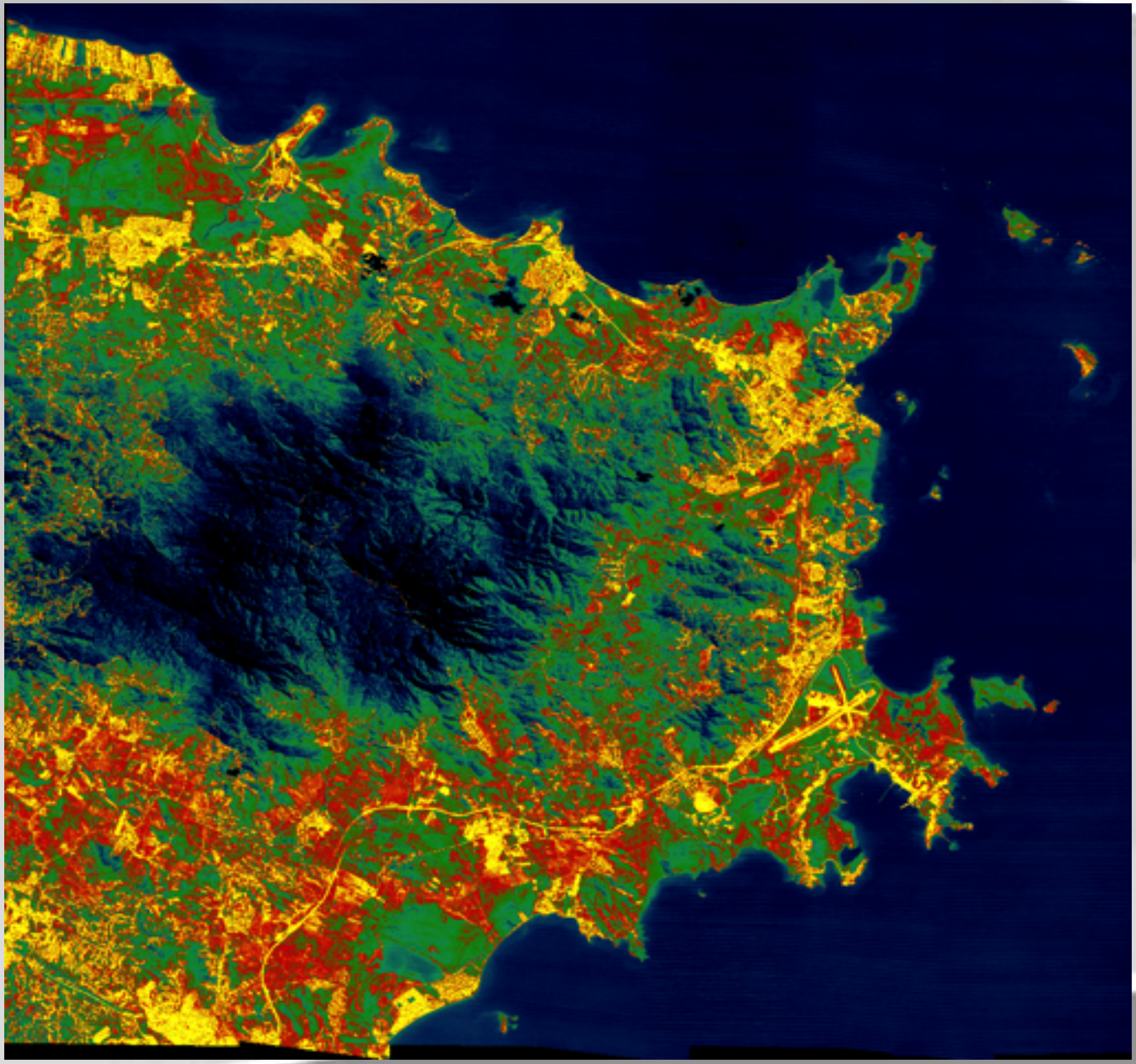
Puerto Rico 10 m ATLAS Thermal Data



Strengths Of Satellite Observations

Measures environmental state functions important to vector & disease life cycles (within vector)

Precipitation, soil moisture, temperature, vapor pressure deficits, wet/dry edges, solar radiation….

***But also the interfaces as process functions*:**

Land use/cover mapping; Ecological functions/structure, canopy cover, species, phenology, aquatic plant coverage…..

And provides a Spatial Context

Spatial coverage & topography – local, regional & global…

Lastly, but perhaps the greatest strength:

Provides a time series of measurements

A Ecological Thermodynamic Paradigm

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The epidemiological equations (processes) can be adapted and modified to *explicitly incorporate environmental factors and interfaces*

Remote sensing can be used to measure or evaluate or estimate *both environment (state functions) and interface (process functions).* The products of remote sensing must be expressed in a way they *can be integrated directly into the epidemiological equations.* The desired logical structures must be consistent with thermodynamic and with probabilistic frameworks.

Challenges

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Satellite Data

- repeat frequency & spatial resolution
- spectral bands available
- clouds
- life cycle
- cost
- data availability & timeliness of delivery

Public Health & Epidemiology

- availability of data & various sampling issues
- difficulty in getting access to sampling areas
- cost
- understanding of the data provided by satellites
- ***Define & quantify the multi-factorial relationships between hosts, agents, vectors and environment***

Surface Radiation Budget

$$Q^* = (K_{in} + K_{out}) + (L_{in} + L_{out})$$

Q^* = Net Radiation

K_{in} = Incoming Solar

K_{out} = Reflected Solar

L_{in} = Incoming Longwave

L_{out} = Emitted Longwave

Surface Energy Budget

$$Q^* = H + LE + G$$

H = Sensible Heat Flux

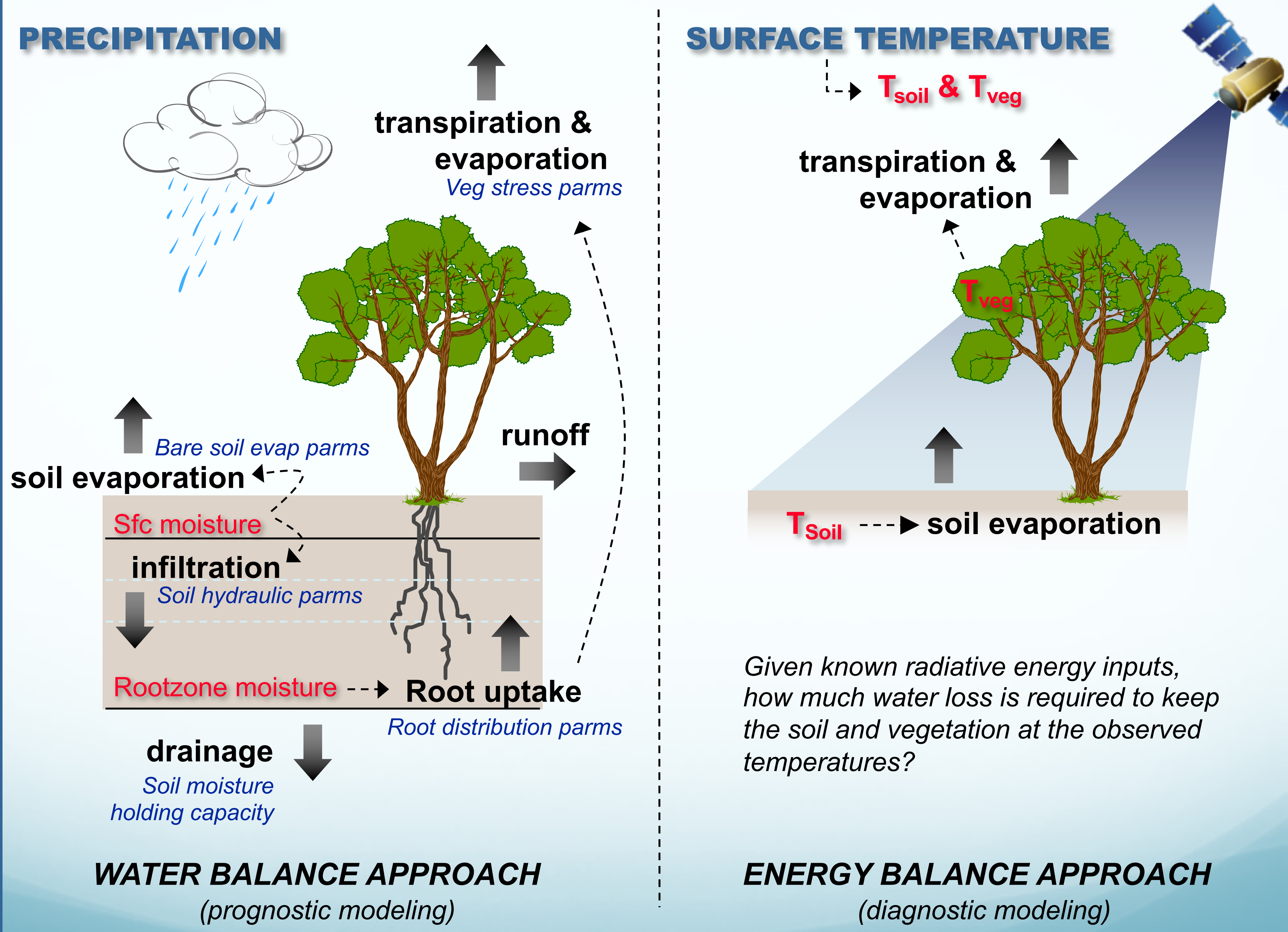
LE = Latent Heat Flux

G = Storage (maybe + or -)

Surface Temperature

$$T_s = T_a + \frac{R_b}{C_\rho}\left(R_n - E\right)$$

Approaches to mapping ET



Martha C. Anderson, et al. *USDA-Agricultural Research Service, Hydrology and Remote Sensing Laboratory, Beltsville, MD*

Thermal Response Number

TRN = Q*/delta T

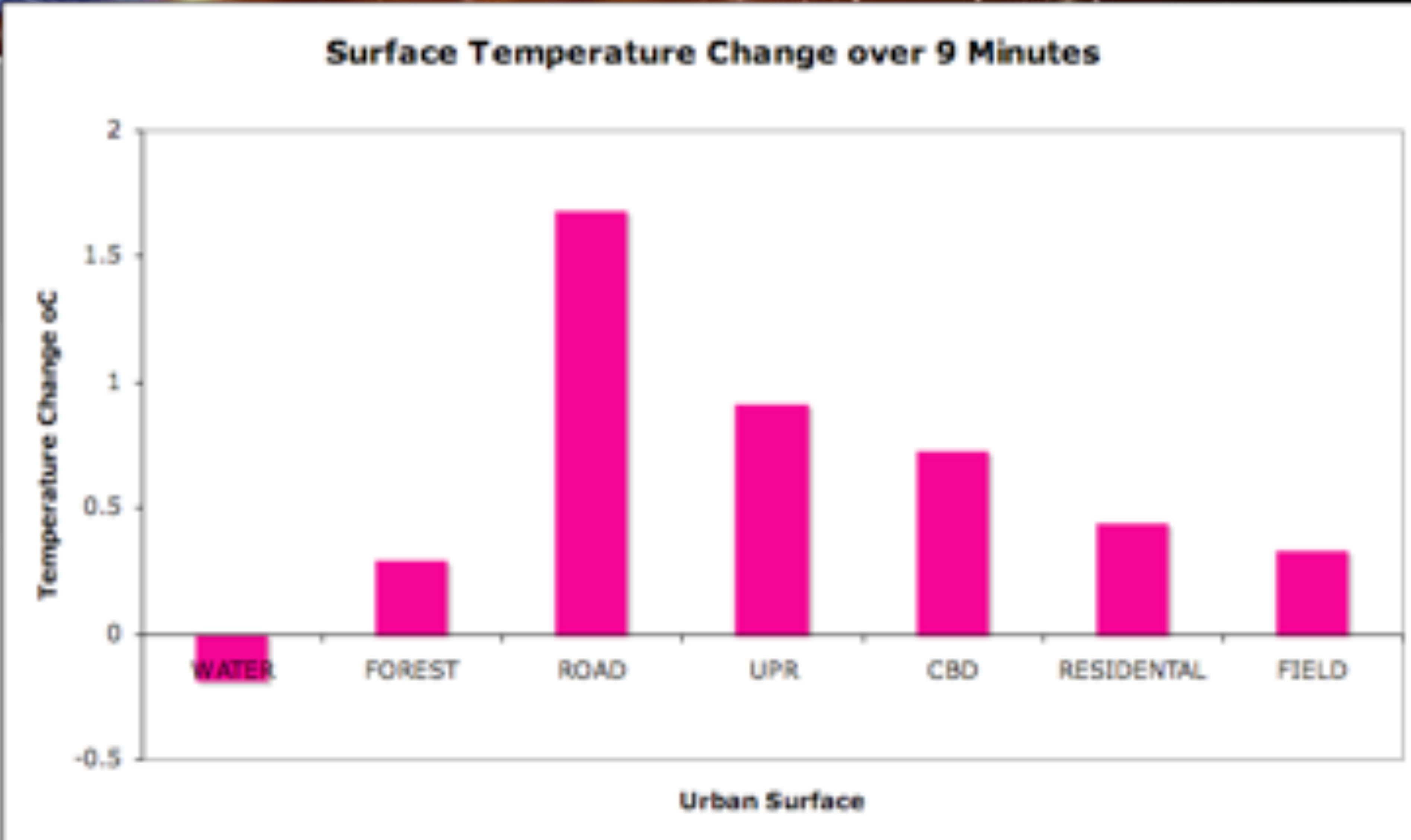
where:

Q* = net radiation

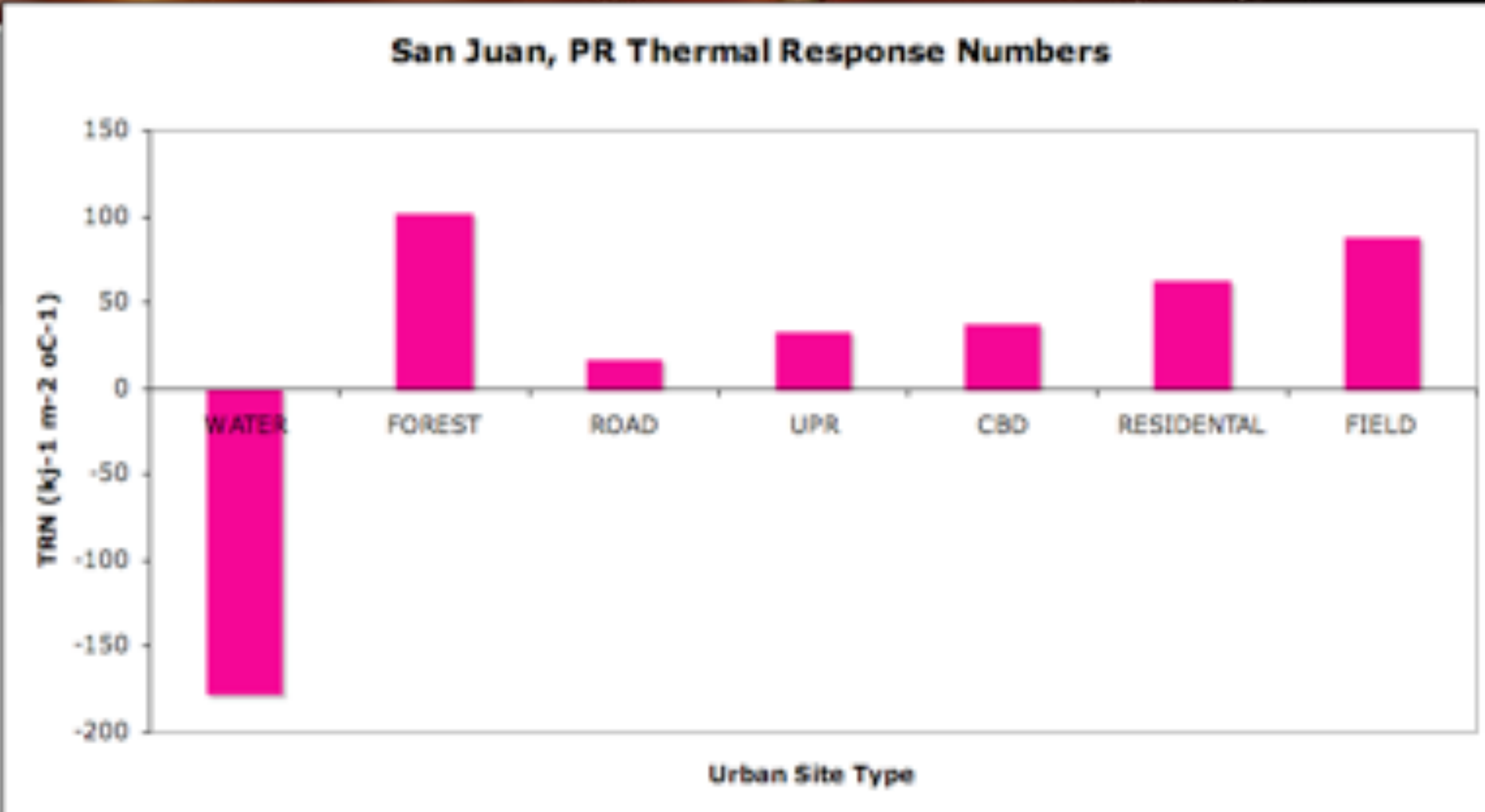
delta T = change in temperature

- Uses the change in surface temperature between 2 measurement times
- Uses surface net radiation as amount of energy available the surface for partitioning
- Produces a quantifiable value (kj m-2 oC -1)
- Allows the classification of land use in terms of energy partitioning

Luvall & Hobo 1989



Surface Temperature Change over 9 Minutes
2
1.5
1
0.5
0
-0.5
Temperature Change oC
WATER
FOREST
ROAD
UPR
CBD
RESIDENTAL
FIELD
Urban Surface

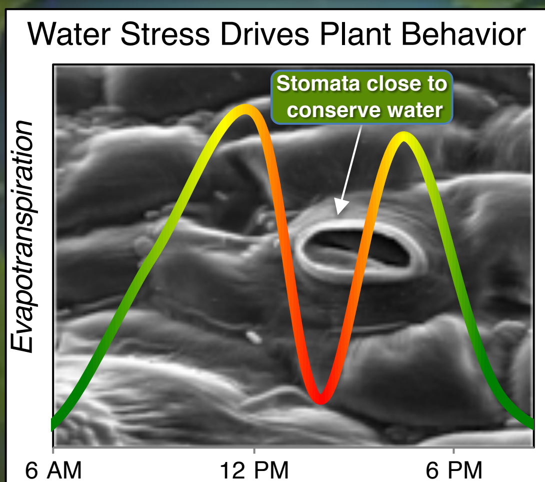

San Juan, PR Thermal Response Numbers
TRN (kj-1 m-2 oC-1)
150
100
50
0
-50
-100
-150
-200
WATER
FOREST
ROAD
UPR
CBD
RESIDENTAL
FIELD
Urban Site Type

ECOSTRESS

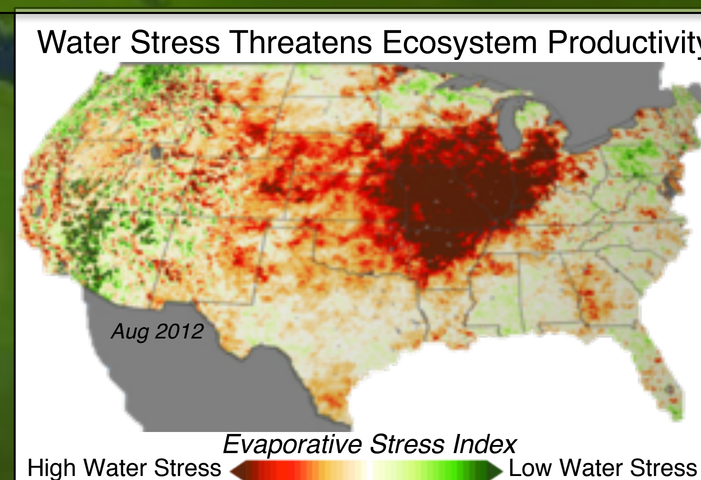
ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

Dr. Simon J. Hook, JPL, Principal Investigator

*ECOSTRESS will provide critical insight into **plant-water dynamics** and how **ecosystems change with climate** via **high spatiotemporal** resolution thermal infrared radiometer measurements of evapotranspiration from the International Space Station (ISS).*



When stomata close, CO_2 uptake and evapotranspiration are halted and plants risk starvation, overheating and death.

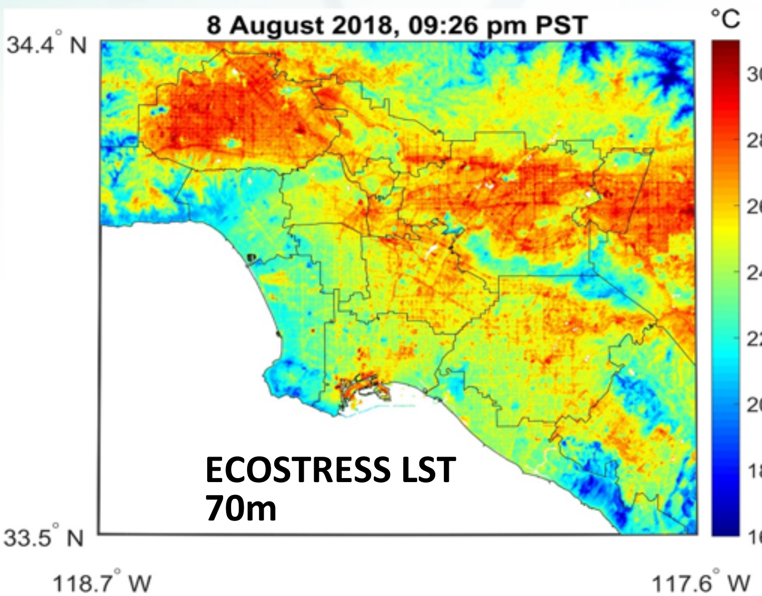


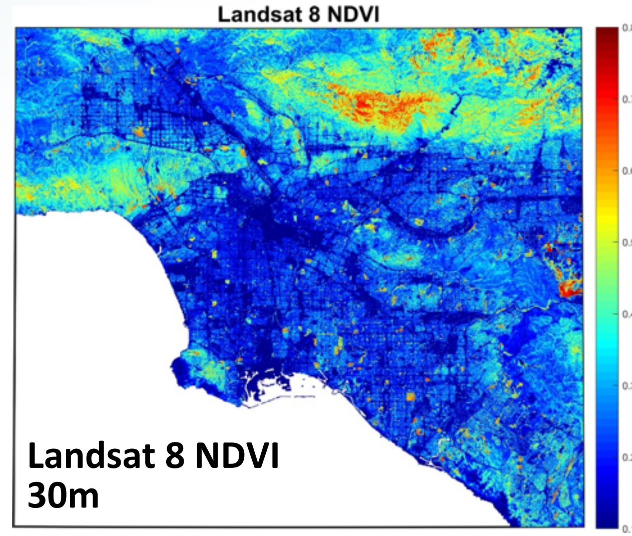
Water stress is quantified by the Evaporative Stress Index, which relies on evapotranspiration measurements.

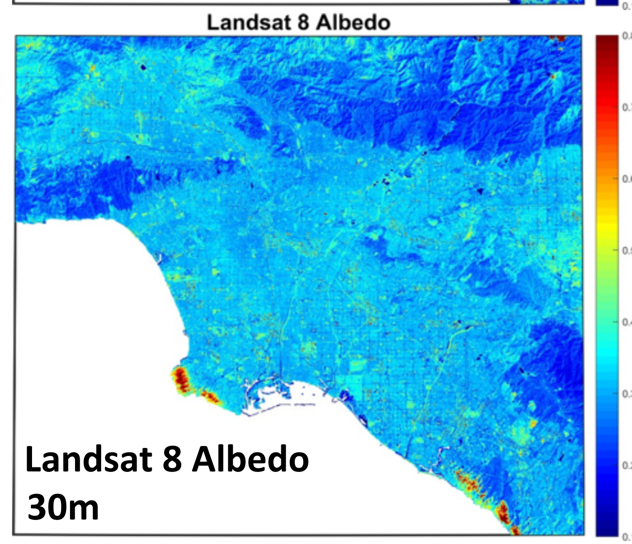
Science Objectives

- Identify **critical thresholds of water use and water stress** in key climate-sensitive biomes
- Detect the timing, location, and predictive factors leading to plant **water uptake decline** and/or cessation over the **diurnal cycle**
- Measure **agricultural water consumptive use** over the contiguous United States (CONUS) at spatiotemporal scales applicable to improve drought estimation accuracy

Are there physical relationships between LST, NDVI and Albedo over the urban environment?



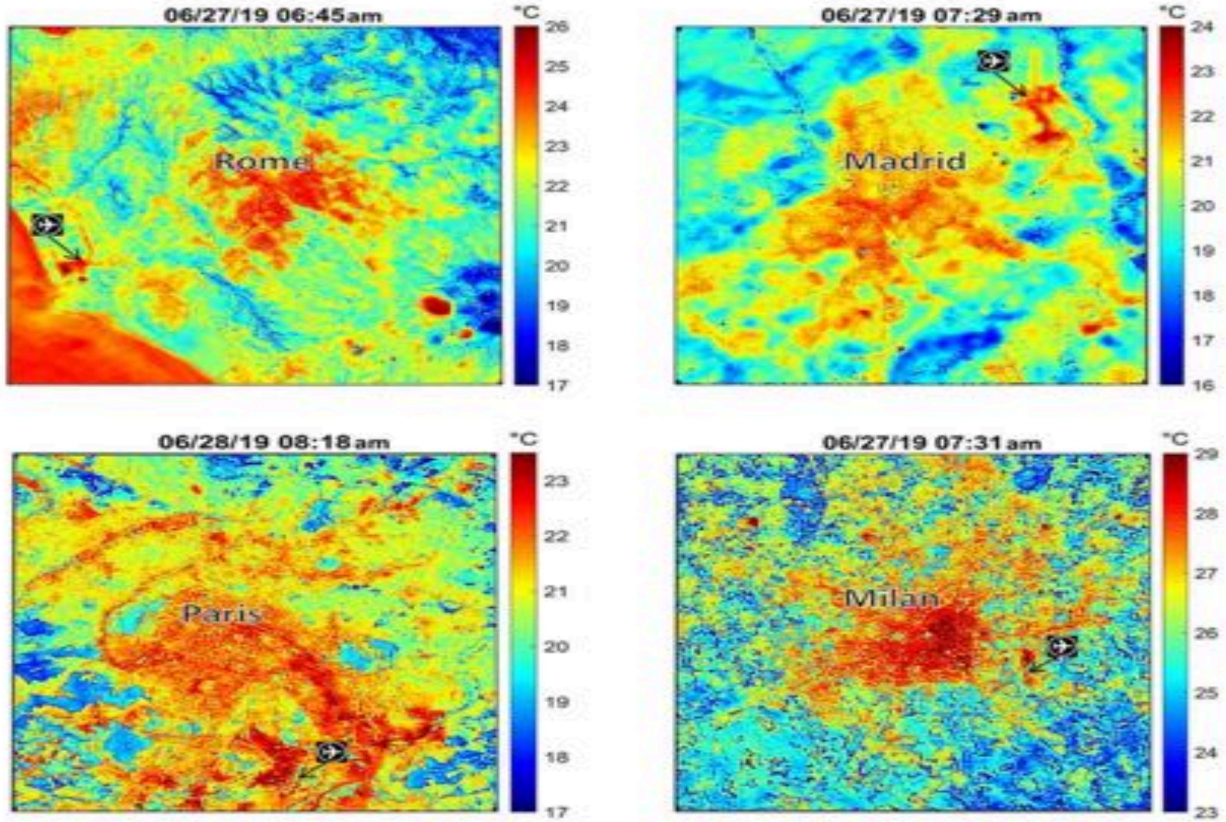




Glynn Hulley[1], Jeffrey Luvall[2]
Panagiotis Sismanidis[3], Iphigenia Keramitsoglou[3]
1. NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
2. NASA Marshall Space Flight Center, Huntsville, AL
3. National Observatory of Athens, Athens, Greece

July 3, 2019

NASA's ECOSTRESS Maps European Heat Wave From Space



These maps of four European cities show ECOSTRESS surface temperature images acquired in the early mornings of June 27 and 28, 2019, during a heatwave. The images have been sharpened to delineate key features such as airports. Airports and city centers are hotter than surrounding regions because they have more surfaces that retain heat (asphalt, concrete, etc.).

Credits: NASA/JPL-Caltech

ECOSTRESS/JPL team &
Glynn Hulley, Christine Lee, Kerry Cawse-Nicholson